V. 2002-03: YEAR FIVE – A NEW BEGINNING

By early 2002, four years of complex intelligent-vehicle research activities had been conducted in Arizona, first with the California ASP-I, ASP-II, and RoadView™ program, and then with the addition of the ADOT-3M commercial lane-awareness technology. Even before the fourth winter test cycle for these two systems in February, ADOT's project sponsors were concerned about the system and roadway infrastructure costs, and were looking in new directions. It was clear that ADOT needed a more realistic approach to provide effective support for its snowplow operators in the range of winter storm conditions that exist all across Arizona.

TECHNICAL ADVISORY COMMITTEE DECISIONS

The overall perspective of the project TAC, even when planning for the fourth winter season with the Caltrans and 3M systems in late 2001, was that the research had developed all of the information that ADOT needed. The TAC still hoped for a heavy winter to better evaluate both ASP concepts on a side-by-side basis, but the basic realities of each were already known.

Both magnet-based concepts were relatively high in their installation cost, and the overall durability of the embedded magnetic materials depends on the useful life of the pavement. The significant vehicle system costs were also a factor. It was clear that Arizona could not deploy either system, as the RoadView ASP was a prototype and 3M had left the market. It was also clear that the current roadway and on-board system costs were not realistic for ADOT.

A new direction was required. The project had developed good information on new advances in vehicle guidance. Rather than simply concluding the program with this knowledge, the TAC still felt the need to investigate other less costly concepts for snowplow operator support. ATRC and the TAC had already discussed many ideas, both internally and with the Caltrans research team. There were several directions that the project might take, but clear guidance was needed.

TAC Survey on Project Directions: Spring 2002

The project sponsors decided to conduct a survey of both the TAC and other key ADOT leaders at the state level. The survey was distributed to these stakeholders in early May. The questions on the key issues after four years included the perceived merits of each system as tested, their significance for ADOT, and what additional research efforts should be made from that point on:

A. System Concepts – Pros And Cons? How Important To ADOT?

- Caltrans roadway-magnet guidance system?
- 3M tape – Lane Awareness System?
- Eaton VORAD collision warning radar?
- GreyLink automatic vehicle logging/tracking (AVL) system?
- Bendix XVision night vision camera (testing proposed)?

B. This Project's Future Directions? What's Your View?

- What have we learned?
- What have we not learned yet?
- What else could the ITS snowplow project study effectively?
- Should this project do more next winter, and if so, where?

The results of the TAC survey dictated a clear change in the future direction of this research. Responses came from the departmental level, the partner districts and maintenance camps, and several of the project's Team Leader snowplow operators. After four years of evaluations, the stakeholder responses on *the future potential in Arizona* for the several guidance and warning systems can be summarized as follows:

Project TAC &Stakeholder Survey – Summer 2002

- Caltrans RoadView Guidance System - Negative
- 3M Lane Awareness System - Neutral
- Collision Warning Radar - Positive
- AVL Tracking System - Negative
- Infrared Night Vision (untested) – Positive

The following paragraphs summarize the stakeholder comments from the survey as well as from the subsequent TAC meeting discussions, which confirmed the new direction for the project.

- **Caltrans RoadView Guidance System** - The key to the TAC's negative rating is that this successful but costly prototype system does not have a deployment potential for ADOT in the near future. It is the more advanced driver-guidance system, but the costs of both the on-board system and the roadway magnets are quite high. The effect on pavement life, the magnet maintenance and durability concerns, and the lack of progress on reducing the installation costs are all negative factors; more testing was not recommended at this time.

- **3M Lane Awareness Guidance System -** The TAC opinions were evenly split on the 3M system, resulting in a neutral rating. It is simple and effective, but costly. It works well, but does not predict the road ahead. Technical support from 3M was very good, but there is no realistic potential to deploy it beyond the single US 89 site, since 3M has given up this market segment. The TAC recommended the continued use of the 3M LAS on US 89 in the following winter, for normal roadway maintenance operations.

- **Collision Warning Radar -** The EVT-300 collision warning radar had favorable ratings in the survey. Driver comments have been positive, but more winter testing is required. The TAC decided that the evaluation of this relatively low-cost, add-on system should continue in Year Five (2002-03). Adaptive cruise control (SmartCruise) will also be installed so that summer testing can be conducted, without the plow blade. This feature has the potential to reduce rear-end accidents year-round, for other vehicle types in the ADOT heavy truck fleet.

- **AVL Vehicle Tracking** - The survey indicated general disappointment with the GreyLink AVL system, and its cellular communications basis, although Caltrans had recommended this system. This was a valuable test overall, showing that the value of a cellular-based AVL system was limited in mountainous rural Arizona operations. The TAC recommended discontinuing the current GreyLink AVL system tests for the 2002-03 winter season.

- **Night Vision (untested)** – The survey response was positive about this low-cost, add-on system. Although procured for testing midway through the 2001-02 snow season, the Bendix XVision unit was not functional until May 2002, when night demonstrations were conducted for project stakeholders. The TAC recommended a full season of winter storm evaluation in 2002-03, to verify this system's potential for Arizona conditions and operating practices.

On-Board Warnings: Low Visibility vs. Zero Visibility

Arizona's extensive four-year test program had been sufficient to support future ADOT decisions on the low-visibility, low-speed operational potential of the two roadway-infrastructure guidance systems. Based on the original goal, to evaluate semi-automated vehicle systems for winter maintenance, both the 3M and Caltrans systems had been thoroughly tested, and while quite effective, their future deployment in Arizona did not appear practical. The experience gained over four winters with the primary and secondary ASP systems was clear enough to lead into a new phase of the project, with further tests of on-board driver-assistance concepts. These fully developed, low-cost, off-the-shelf commercial warning systems could directly benefit the ADOT snowplow operators, and therefore the public, during winter storms.

The ATRC was directed to deploy new on-board systems across the I-40 Corridor for the 2002-03 winter evaluation program. Based on the research project budget available after four winters, it was decided to supplement the CWS radar on ADOT-3M snowplow F342 with three more units, and to purchase two more XVision systems in addition to the one unit recently installed.

This budget-limited plan would deploy a total of seven on-board warning systems in the field. On this basis, with initial contacts already having been made, the ATRC initiated negotiations with both Eaton and Bendix.

SCOPE EXPANSION: THREE DISTRICTS

A long-standing problem with the ASP evaluations had been the inability to train snowplow operators in storm conditions, since trainees could only come to the Flagstaff test lanes during fair weather and in daylight. With the new on-board systems, the research would not depend on specific test sites, and there would be no need for group training in the coming 2002-03 season.

There were other potential issues in switching to on-board systems. A significant new challenge would be to retain the active participation of those project stakeholders who were being sidelined by the shift away from vehicle guidance systems.

With these issues in mind, the project TAC decided that a logical and practical new evaluation concept would be to deploy additional systems in other districts apart from just Flagstaff. This approach would expand the operator pool and increase both systems' exposure to local severe storms, as well as to statewide or regional storms. On that basis, therefore, the Holbrook and Kingman districts would each be allocated additional on-board systems for evaluation.

Each district, including Flagstaff, was asked to assess their own local conditions, and select a snowplow and a key route for testing with each of the new warning systems. The three districts assigned the evaluation systems to seven key snowplow routes, as highlighted in Figure 7 (Note: both Eaton VORAD and 3M systems are installed on the ADOT-3M snowplow).

For each project snowplow, the primary local route assignment is identified in Table 4. There would be three snowplows in the Flagstaff District with on-board systems for evaluation. The other partner districts, Kingman and Holbrook, each would deploy one EVT-300 radar system and one XVision infrared system. Most of the research plows were assigned to the I-40 Corridor, and the other test route segments connect with I-40. In a major regional winter storm, all of these snowplows would be fully engaged.

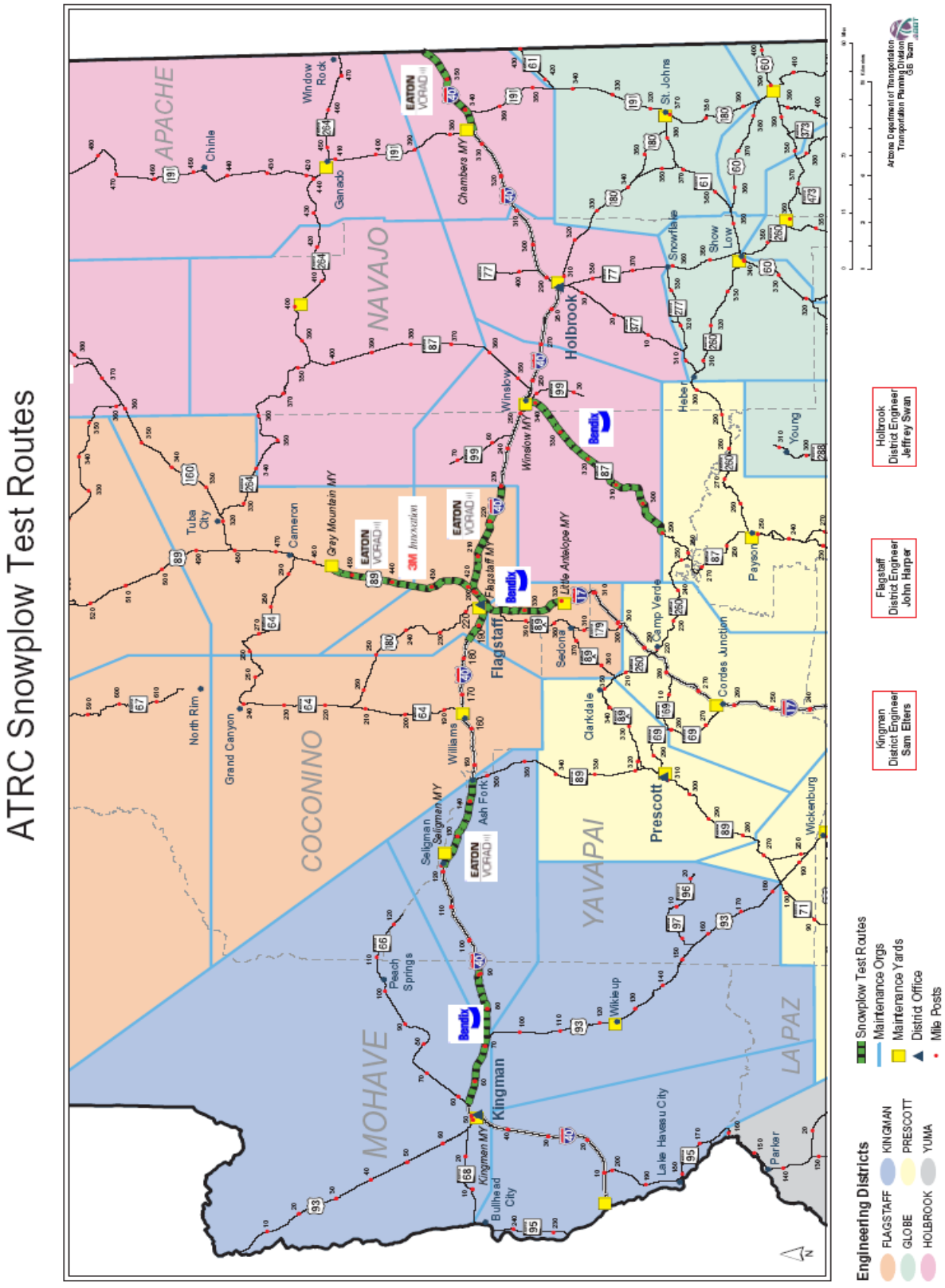

Figure 7: Seven On-Board Systems Evaluation Routes For 2002-03

Table 4: Route Assignments of Project Snowplows: Year Five

2002-03 - Research Snowplows with On-Board Systems					
Snowplow	Maintenance Camp / Yard	ADOT District	Route	Milepost Limits	System
F235	Little Antelope	Flagstaff	I-17	335 – 340 to 40/17 interchange	XVision
F269	Chambers	Holbrook	I-40	347 – 360	EV Radar
F277	Kingman	Kingman	I-40	54 – 72	XVision
F291	East Flagstaff / Green River	Flagstaff	I-40	185 – 230	EV Radar
F326	Seligman	Kingman	I-40	121 – 146	EV Radar
F340	Winslow	Holbrook	SR 87	317 – 290	XVision
F342	Gray Mountain	Flagstaff	US 89	420 - 440	EV Radar & 3M

The project had already gained extensive experience with collision warning radar systems. Since 1998, each evolution of the RoadView ASP had given ADOT more exposure to Eaton VORAD's technology as integrated and further refined by the Caltrans program team. Ultimately, the same EVT-300 commercial system had been chosen in late 2000 to equip the ADOT-3M plow, F342.

There was also stakeholder interest in night vision systems for both highway maintenance and for law enforcement. As early as mid-2001, Bendix marketed their XVision passive-infrared system to ADOT and to the Arizona Department of Public Safety (DPS).

Initially, XVision was considered to augment the radar system on the ADOT-3M snowplow, but combining the two was not practical due to truck cab space and system power limitations. By the time of the ATRC-TAC survey in mid-2002, however, a trial XVision system had already been demonstrated to the project stakeholders on Little Antelope Camp's snowplow F235, as indicated by the survey comments presented previously.

Phase Three Program Issues: Procurement, Costs, Budgets

The redirection of the Year Five project effort required the ATRC to establish relationships with two new suppliers to develop the research plan and evaluation approach. Both on-board systems were commercial products, but each was conceived as a driver-support system for long-haul transport fleets. The CWS radar system was already widely distributed, and the Eaton VORAD marketing program was not specifically focused on "niche markets" such as snowplowing. The Bendix infrared night vision system was just beginning to be widely marketed at that time, and their program was still exploring the potential for specialty vehicle applications.

A primary concern was to confirm the terms and procurement approach to obtain the two new systems for the research project. The ATRC faced a variety of procedural challenges with regard to procurement processes, as the ADOT commercial equipment sourcing requirements differed for the Eaton and Bendix suppliers. The XVision systems were procured through existing ADOT contracts with local Bendix equipment vendors, but a separate new contract was needed with Eaton Corporation to acquire the EVT-300 systems for evaluation.

ADOT-ATRC Experience with Eaton

ADOT had already gained considerable experience with the Eaton VORAD EVT-300 collision warning radar system (CWS), initially through the Caltrans RoadView ASP program. As noted in previous ATRC and AHMCT project reports, the Caltrans system used EVT-200 and –300 components for the forward warning feature of its integrated driver-vehicle interface (DVI). However, the Caltrans development team had extensively refined the collision warning system on the ASP, in order to provide more advanced target interpretation data and more specific warning information to the operators.

ATRC had also had procured an off-the-shelf commercial EVT-300 radar unit in mid-2000, as part of the initial development of F342, the ADOT-3M advanced snowplow. The ADOT-3M research plow was equipped with this CWS radar to approximate the suite of driver-assistance technologies used by the Caltrans snowplow.

The EVT-300 as installed on plow F342 was an off-the-shelf standard CWS unit, and it provided exactly the same features and warnings as the identical units already in use by numerous major trucking fleets across the country. However, it had to be installed on the cab roof in order to "see" clearly over the six-foot high ADOT snowplow blade.

ADOT-ATRC Experience with Bendix

As noted earlier, the ATRC and ADOT Equipment Services had already been in contact with Bendix Commercial Vehicle Systems in regard to their earlier testing of the XVision infrared night vision camera in other regions of North America. The caveat to testing in Arizona was that XVision was still in the final stages of development. However, this situation provided an early opportunity to evaluate the concept in a beta-test scenario, resolving ADOT's questions while supporting the further refinement of the system.

The ATRC approached Bendix in mid-2001, but the test plan could not be initiated until the next spring, too late for any snowplowing in the Flagstaff area. Bendix provided an initial evaluation unit to ADOT in January 2002, which was installed in February. No significant operations were carried out, however, due to unrelated truck problems. A night demonstration of XVision for the project TAC and partners was finally conducted in May at Rim Camp on US 89A near Sedona, and the stakeholder reactions were uniformly positive.

PHASE THREE PROGRAM VISION

For snowplow operators, restricted visibility in wind-blown drifting snow and the "snow cloud" that the snowplow blade generates around the truck are major hazards. In a heavy storm, on icy roadways, snowplow drivers have much worse visibility than any others, especially those in the high cabs of tractor-trailer rigs. At the same time, these conditions can hide moving cars, stalled cars, fallen rocks or trees, or animals or people in and along the roadway.

The project goal for Phase Three was to determine the key factors for successful implementation of commercial radar and night vision warning systems for snowplowing in rural states such as Arizona, and to determine the state of development, effectiveness, flexibility and reliability of each system in storm conditions.

The fundamental problem to be addressed by this ADOT research program is poor visibility for snowplow operators in severe winter storms. The new on-board warning systems do not provide predictive guidance abilities to keep the plow moving in very poor visibility, as do the 3M or Caltrans ASP concepts, but they do improve operator awareness of the conditions and potential obstacles in the road ahead.

The project TAC had directed that at least two snowplows in each of the partner district were to be equipped with either the EVT-300 radar system or the Bendix XVision system for 2002-03. The following chapters of this report describe each system, and its initial and wider deployment, in more detail.